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(54) PROCESS AND APPARATUS FOR POSITIONING A VERTICALLY MOVABLE PLATFORM IN FRONT OF A TARGET LOCATION

(71) We, OEHLER-, WYHLEN-LAGERTECHNIK A.G. a Swiss Company of Industriestrasse 44, CH-5000 Aarau, Switzerland, do hereby declare the invention,

for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to method and apparatus for positioning a vertically movable platform in front of a target location such as a storage bay containing pallets.

It is known that one source of technical problems in high-bay storage with fully automatic control of the conveying means, is that the pallets being put into or removed from storage are made of wood and have relatively wide manufacturing tolerances, and that the dimensions of these pallets can change in the course of time through use, wear, fatigue of the wood, etc. Further complications in such bay storage stem from the facts that economic considerations prevent the individual bay units from being built with very high dimensional accuracy and that they can shift from their proper positions as a result of settling or external factors such as wind pressure, differences in thermal stressing etc. Particularly in the case of a warehouse of considerable length or height, these factors accumulate to such an extent that proper functioning of the automatic control of the conveying means may be no longer practical.

It has already been proposed that square pieces of light-reflecting foil be mounted on each target location containing pallets as positioning markers and that these be scanned by four beams of light emitted by optical transmitters on the lifting carriage of the conveying means. This made it possible to detect the precise position of the target location, hereinafter referred to at "pallet location," but this advantage was offset by the fact that the optical scanning system gave rise to malfunctions and also required substantially more maintenance in order to counteract contamination of or damage to the relatively large surfaced, light-reflecting foils. Moreover, optical scanning usually necessitates a conversion of the signal provided by a photoelectric cell, and can only be applied in a trial-and-error procedure with corresponding loss of time.

Further, the optical procedures employed to date are not operable in cases where a relatively small, local fire results in dense smoke. But that is preceisely the moment when it would be especially desirable to remove goods in the neighbourhood of the fire with remote-controlled conveying means in order to prevent the fire from spreading and/or damaging the goods.

In the known optical systems, further malfunctions occurred when the illumination intensity was altered by additional light effects.

The present invention provides a process for the fine positioning of a vertically movable platform at a target position in front of a pallet location, such as a storage bay, comprising:

vertically moving the platform to an initial approach position lying above the target position by means of an automatic control system;

actuating sensing means on said platform after said approach position has been reached;

lowering the platform and the sensing means unitl the sensing means indicates that a predetermined distance from a reference point on said pallet location has been reached, in which process the sensing means is an infrared transmitter arranged on the platform and emitting, in use, a modulated, collimated beam of radiation, said beam being focussed on a pre-

determined point on the pallet location as the platform is lowered to cause said beam to be reflected diffusely from the pallet location, the diffusely reflected beam being then received by a receiver arranged to receive only within a preset angular range corresponding to predetermined distances between said platform and said predetermined point on the pallet location.

The scanning of the pallet location is therefore effected with modulated radiation in the infrared band, said radiation being emitted by a transmitter arranged on the platform, reflected from a predetermined point on the pallet location and received by a receiver arranged on the platform in a certain position of the platform opposite to the pallet location, whereby the receiver actuates a control system for the movement of the platform.

The invention further provides apparatus for the fine positioning of a vertically movable platform at a target position in front of a pallet location comprising an automatic control system for moving the platform to an initial approach position lying above the target position, a transmitter on the platform for emitting a modulated collimated beam of radiation in the infrared band, means directing said beam toward said pallet location, receiving means arranged on the platform at a distance from said transmitter for receiving diffusely reflected radiation from said pallet location, said receiving means being adjustable to delimit the radiation received to that which is reflected within certain predetermined angular ranges which correspond to predetermined distances between said platform and said pallet location and being responsive to the absence of such reflected radiation for causing said control system finely to position said platform with respect to said pallet location.

It is particularly advantageous for the receiver to include photodiodes, particularly silicon diodes, which respond with special sensitivity to infrared waves and which can be employed as switching elements in the control circuit.

The transmitter advantageously comprises a micro-laser which is in use pulsed at short intervals to modulate the beam of radiation emitted by the transmitter.

The invention will now be explained in detail with reference to the accompanying diagrammatic drawings of preferred embodiments. In the drawings:

Figure 1 is a diagrammatic view of one embodiment and

Figure 2 is a diagrammatic view of an embodiment similar to but more developed than that shown in Figure 1.

In Figure 1, 21 represents a transmitter which in use generates a focussed light beam 22 in the infrared band and is carried by the platform of a pallet transfer tower (not shown). The transmitter used may for example, be a microlaser which emits a modulated coherent beam largely insensitive to (i.e. non-interfering with) external light. The light beam 22 even penetrates clouds of smoke and spray or fog without significant impairment. This light beam 22 strikes the front face of a pallet location 23' and shows on it as a spot of light. The reflection is diffuse, hence no special reflecting surface is required. Arranged on the platform and a predetermined distance away from the transmitter 21 is a receiver 25 in the form of a photodiode, which can only receive reflected beams 24 within a certain angular range, 26 represents an adjustable aperture placed in front of the photodiode 25; this aperture can be used to delimit still more precisely the direction of the reflected beam. Hence the adjustable visibility range of the receiver 25 makes it possible to establish the distance within which objects can be located with the beam 22.

In the practical application of the described system, which is similar to that described more fully in relation to Fig. 2 below, it is advantageous to use two scanning devices, such that the second device permits the additional determination of whether the target pallet location is full or empty. This improves still further the reliability of the storing and removal procedure.

Figure 2 shows a scanner group A and a scanner group B arranged on the lifting platform, whereby the group B is offset in relation to group A both in height and laterally in order to prevent light-beam interference.

The scanner group A has a transmitter 21 and light beam 22, the latter striking an object 23 in pallet location F. When the platform is in front of the location F the reflected beam 24 passes the adjustable aperture 26 and reaches the photodiode 25. This device establishes whether the bay F is full or empty. Only when the pallet location or bay is full can the beam 22 be reflected in such a way that part of the reflected beams penetrate the aperture 26 to reach the photodiode 25.

The scanner group B makes possible the fine positioning of the platform and comprises a transmitter 27 and a receiver 28 in the form of a photodiode behind an adjustable aperture 29.

If the platform is to be run to a full pallet location F and the goods therein are to be removed and carried away, the platform is first moved by an automatically functioning control system (not shown) into an approach position somewhat above the

target pallet position F. During the last portion of the travel of the platform, the scanner group B is switched on and the platform is lowered again slowly. The infrared beam 30 emitted by the transmitter 27 was originally directed toward an empty cavity under the pallet 33; it then strikes the edge 34 of a structural beam 32 of the storage compartment or bay, i.e. pallet location, and the resulting ray of light is picked up by the receiver 27. As the platform is lowered further the spot of light disappears suddenly, so that the beam 30 is no longer reflected. Thus the previously reflected beam 31 disappears, providing a signal in the receiver 28 which is utilized in the well-known manner to halt the platform movement. The position of the receiver 28 is chosen so that the target position of the platform is reached precisely when the reflected beam 31 disappears. In this position the goods to be removed can be picked up and taken out of the pallet location F.

According to a modification not illustrated, a further photodiode can be arranged below the aperture 29, and somewhat offset therefrom. If neither of the photodiodes receives a light signal, the platform is still too high. If the receiver 28 receives a light signal but the additional photodiode still receives none, the platform is still too high but the receiver 28 prepares the circuit for the halting. If the light signal disappears at the receiver 28 and the additional photodiode does not yet receive a signal, the position of the platform is correct and its movement is interrupted instantly. Finally, it can be arranged that the light signal disappears at the receiver 28 and the additional diode receives light. In this case the platform is located too low because the desired target position has been passed. During the subsequent upward movement, the platform is halted when the light signal disappears at the additional diode and no light signal has yet reached the receiver 28.

The invention is not intended to be restricted to the embodiments described. Thus, for example, the microlaser can be replaced by an infrared lamp with convergent lens, wherein the light is modulated by a rotating slotted disc. Moreover, phototransistors can be employed instead of photodiodes. Another type of transmitter which could be used is a gallium arsenide diode which generates an infrared carrier wave with a wavelength of about 0.9 microns, which is focussed by a telescopic optical system.

The preferred embodiments described make it possible for the platform to assume an optimum position relative to the target location in every case before the means for picking up the load are run into the location. It makes no difference, for example, if a heavily loaded target has sunk or settled somewhat, since the sensor detects the precise position of the upper edge of the target in each. This also takes into account any tolerances in the dimensions of the bays, so that reliable operation of the automatic control system without time loss is assured.

WHAT WE CLAIM IS:—

1. A method for the fine positioning of a vertically movable platform at a target position in front of a pallet location, such as a storage bay, comprising: vertically moving the platform to an initial approach position lying above the target position by means of an automatic control system; actuating sensing means on said platform after said approach position has been reached; lowering the platform and the sensing means until the sensing means indicates that a predetermined distance from a reference point on said pallet location has been reached in which process the sensing means is an infrared transmitter arranged on the platform and emitting, in use, a modulated, collimated beam of radiation, said beam being focussed on a predetermined point on the pallet location as the platform is lowered to cause said beam to be reflected diffusely from the pallet location, the diffusely reflected beam being then received by a receiver arranged to receive only within a preset angular range corresponding to predetermined distances between said platform and said predetermined point on the pallet location.

2. Apparatus for the fine positioning of a vertically movable platform at a target position in front of a pallet location comprising an automatic control system for moving the platform to an initial approach position lying above the target position, a transmitter on the platform for emitting a modulated collimated beam of radiation in the infrared band, means directing said beam toward said pallet location, receiving means arranged on the platform at a distance from said transmitter for receiving diffusely reflected radiation from said pallet location, said receiving means being adjustable to delimit the radiation received to that which is reflected within certain predetermined angular ranges which correspond to predetermined distances between said platform and said pallet location and being responsive to the absence of such reflected radiation for causing said control system finely to position said platform with respect to said pallet location.

3. Apparatus according to claim 2, wherein said receiver electrically cooperates with a control circuit forming part of said

control system for directing movement of said platform.

4. Apparatus according to claim 2 or 3 wherein the receiving means comprises photo-diodes selected so as to respond with specific sensitivity to infrared waves.

5. Apparatus according to claim 2, 3 or 4 wherein said transmitter comprises a micro-laser which is in use pulsed at short intervals to modulate the beam of radiation emitted by the transmitter.

6. Apparatus according to any of claims 2 to 5, wherein said receiving means includes an aperture for limiting the beam of radiation received by said receiving means.

7. Apparatus according to claim 2, wherein said transmitter and said receiving means cooperate to constitute a first scanner group, there being a second scanner group which comprises a second transmitter and a second receiving means arranged on said platform, said scanner groups being in offset relationship with respect to each other both in the vertical and horizontal directions to prevent interference between the separate beams emitted from each respective transmitter and the beams received by the respective receiving means.

8. Apparatus according to claim 7 wherein the receiving means of one of said scanner groups causes the platform to stop when a reflected beam incident on said receiving means ceases to strike said receiving means as a consequence of a change in the angle of incidence of said reflected beam.

9. Apparatus according to claim 7 or 8, wherein one of said scanner groups further comprises an additional photodiode acting as an additional receiving means arranged such that a reflected beam is received by the respective receiving means of said scanner group serially as the platform is vertically displaced, said receiving means cooperatively influencing the movement of the platform with respect to the pallet location and causing said platform to stop when the reflected beam is no longer incident upon each of the receiving means of said one scanner group.

10. Apparatus according to any of claims 2 to 9 wherein the or each said transmitter comprises an infrared lamp with a convergent lens system and a rotary slotted disc for modulating the radiation emitted from said lamp.

11. Apparatus according to any of claims 2 to 9 wherein said transmitter comprises a gallium arsenide diode for generating an infrared carrier wave having a wavelength of approximately 0.9 microns, and a telescopic optical system for focussing said carrier wave.

12. A method as claimed in claim 1 substantially as hereinbefore described with reference to Fig. 1 or Fig. 2 of the accompanying drawings.

13. Apparatus as claimed in any of claims 2 to 11, substantially as hereinbefore described with reference to and as shown in Figure 1 or Figure 2 of the accompanying drawings.

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COMPLETE SPECIFICATION

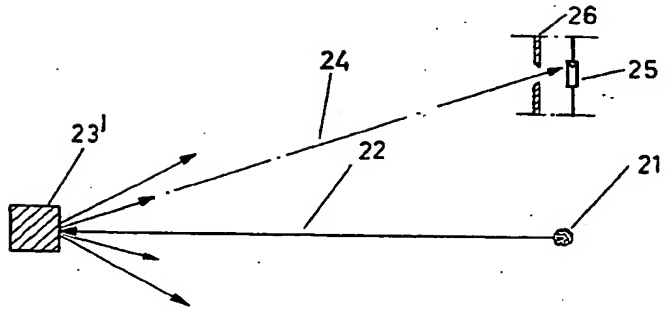

Fig. 1

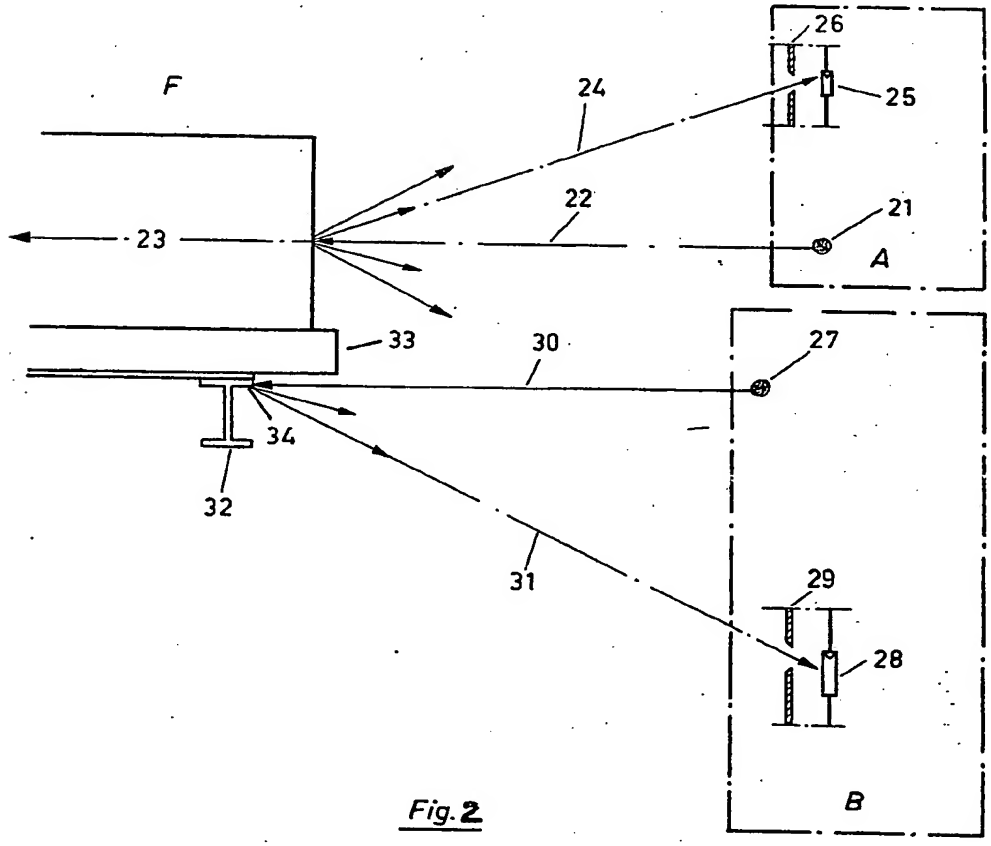

Fig. 2